

A fresh look at chemical fossil extraction

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In this age of microtechnology, now more than ever before, detail is indispensable. In the past, the damage to fossils during retrieval, preparation and storage was an accepted downfall of the scientific process. With the increasing use of advanced techniques, which rely on high-resolution applications such as scanning electron microscopes and microtomography, there is a definite need to improve on the actual fossil extraction methods currently used. The aim of this work is to achieve an ideal method of extraction where the fossil is retrieved in its entirety without adding or taking away any evidence whatsoever.

Chemical preparation of vertebrate fossils has been used since the late 19th century, and as early as 1908 was described by Bather (Lindsay 1987; Rixon 1976). The process involves the immersion of calcareous fossil-bearing rocks into aqueous solutions of organic acids (Rutzky *et al.* 2005). Even when only a small percentage of the matrix is calcium carbonate, the acidic action will break down the structure and therefore the cohesion of the rock (Toombs & Rixon 1959). In recent years, chemical preparation and in particular, acid preparation has received bad press. This is mainly due to the inferior methods and materials used in the past, resulting in damaged fossils. It also poses a health and safety risk to the preparator and requires stringent protective measures, such as stable temperatures, masks, gloves and good ventilation. This said, acid preparation remains the only reliable method of retrieving certain fossils, including microfossils or really delicate specimens, from a calcareous matrix (Rixon 1976). Chemicals are able to access areas that mechanical tools can never reach and differentiation between matrix and fossil is more subtle and accurate (Lindsay 1987). Acid preparation has the advantage of gradually revealing fossils hidden below the matrix surface. This eliminates any assumption on the part of the preparator (Cooper & Whittington 1965).

In this ongoing study, experiments are being conducted using new and old techniques in order to improve on the speed and efficiency of fossil extraction from different matrices without sacrificing the quality of the finished product, ideally an undamaged fossil. The aim is to develop a more controlled and empirical method of chemical preparation. It is extremely important that the various steps and observations along the way are fastidiously recorded (Shelton & Chaney 2005). Records of materials and methods were often not kept in the past and this poses problems for modern conservation and curation (Lindsay 1987).

All Plio-Pleistocene-aged material from the Cradle of Humankind World Heritage site prepared at the Transvaal Museum is chemically retrieved. Acetic acid ($C_2H_4O_2$) is used, as it dissolves limestone and other rocks that contain carbonates (Stringer *et al.* 1985), but bones and teeth, mostly composed of calcium phosphate are resistant to it (Lindsay 1987; Rixon 1976). Blocks of breccia are photographed and thoroughly investigated with the weights, densities and colours recorded. A sample of the matrix is ideally removed before acid treatment and retained for future study (Rutzky *et al.* 2005). A thin coat of consolidant, usually Paraloid B-72 (an ethyl methacrylate copolymer, known as Acryloid in the United States) is painted onto any exposed bone. The consolidant not only protects the bone from the acid, but also reinforces it for future storage in a collection. Paraloid is a thermoplastic resin, soluble in acetone, but resistant to water and acids. It is non-yellowing, has a low-gloss and is extremely flexible (Hamilton 2007). Once applied, the consolidant must be allowed to dry thoroughly for at least 24 hours to prevent the acid from lifting the protective coating and attacking the bone. The blocks are immersed in diluted acetic acid ($C_2H_4O_2$). It is prudent to start at a low concentration of about 6% until the reactivity of the subject matter is determined. It is very important to ensure complete immersion in the liquid, as exposure of any part of the blocks to air will result in calcium acetate salts forming in the bone, causing cracking (Rixon 1949; Stringer *et al.* 1985). This is extremely destructive to the specimens and many fossils prepared in the past are now showing signs of calcium acetate damage. The blocks are usually left immersed in the solution for 24 hours, after which they are removed and the liquid is strained off using a fine mesh. The block and any sediment related to it is then neutralized by flushing with running H_2O for twice to three times longer than it was subjected to acid treatment (Rixon 1949). After the allotted time, the liquid is strained off and all sediment is gathered and labelled for sorting. The blocks are dried thoroughly and any newly exposed bone is painted with consolidant. The process is then repeated and the strength of the acid (up to about 8%) is adjusted accordingly until the entire block has been broken down into sediment. It would appear that the corrosive action actually accelerates briefly after each introduction of H_2O . This needs to be kept in mind when devising a suitable preparation plan. It is worth considering whether the fossil would be better suited to stronger concentrations and fewer immersions as opposed to multiple immersions into weaker solutions.

Various experimental techniques are being investigated. The entire process may be sped up by the gentle heating of an acid; in fact, even natural sunlight proves to be an effective catalyst. Electrochemical dissolving has proved to speed up the process considerably. This technique involves passing a current through a decalcifying electrolyte, causing the movement and separation of ions to electrodes of different polarity. Electrolysis of this kind has allowed for preparation time to be shortened drastically and the strengths of the acid concentration to be dropped significantly (Kulich 1991). Localizing the corrosive action on unwanted sediment is often preferable to stressing

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sensitive specimens by repeated immersion in chemicals. This may be achieved by constraining the chemical within a carrying agent, such as a water-based lubricant, in order to focus on particular areas that need preparation, while avoiding unnecessary contact with the fossil.

Different chemicals are currently being experimented with. The acids used in this study are: acetic acid ($C_2H_4O_2$), formic acid (CH_2O_2), nitric acid (HNO_3), sulphuric acid (H_2SO_4), phosphoric acid (H_3PO_4) and hydrochloric acid (HCl in H_2O). Bases include hydrogen peroxide (H_2O_2) and sodium hydroxide (NaOH). The most compatible consolidant for each corrosive chemical is sought out through a process of systematic elimination. Samples from various fossiliferous deposits from South Africa, ranging from the Permo-Triassic (Lower Beaufort) to Plio-Pleistocene (Cradle of Humankind) are subjected to varying strengths of different chemicals and closely monitored. This investigation aims to determine the correct chemical for the job at hand.

Great care needs to be taken when working with corrosive agents. Compatibility of different chemicals needs to be thoroughly investigated before new substances are introduced into the laboratory (Rixon 1976).

Sincere thanks to the Francis Thackeray, Dominique Gommery and the HOPE team for their endless confidence and support. Thanks are also expressed to Brett Driessing of Protea Chemicals for advice and chemical samples and to Tersia Perregil and Johann Neveling for their time and assistance.

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